NASA TECH BRIEF

Cooling of 2KW H_2–O_2 Fuel Cell

An extensive research and development program has been carried out to devise an improved method of removing waste heat of reaction from a developmental 2KW H_2–O_2 fuel cell. The objectives of this effort were to eliminate an intermediate heat exchanger, increase system reliability, improve thermal performance (to reduce radiator requirements and enable the fuel system to accept a greater range of coolant temperatures), and to reduce system cost and weight.

In one method which was developed, waste heat of reaction is removed from the fuel cell by conduction through the cell plates, via a suitable thermally conductive electrical insulator, to channeled cold plates. Coolant is passed through the cold plates on two sides of the cell stack, and heat is removed from the stack by conduction through the cell plate edges and the cold plates. The flow channels are of rectangular cross section to take advantage of the large heat transfer coefficients associated with high geometric aspect ratios. The cold plates are constructed of aluminum, and all welding is performed by the electron beam process. The insulating medium is a 0.007-inch-thick layer of a silicone polymer loaded with magnesium oxide to improve thermal conductivity. This insulation is a resilient material capable of compensating for small irregularities in the surface formed by the cell plate edges. Fuel cell temperature is controlled by varying the flow rate of the coolant through the cold plates. The basic design of the cooling system can be adapted to allow various flow patterns and manifolding arrangements without altering the fuel cell stack or other components.

A water cavity, heat pipe cooling method, which was investigated, requires further development. This method would have potential application to all fuel cell systems using the static moisture removal method of collecting fuel cell product water. At a current density of 200 amperes per square foot, approximately 33 percent of fuel cell waste heat of reaction is removed as latent heat of vaporization at the water removal matrix and is rejected to the coolant at the water condenser. Water, supplied from the recovery subsystem at approximately 60 psi, is injected either into the oxygen or hydrogen cavity; the water is then removed as vapor with the product water. Fuel cell temperature is controlled by the frequency, duration, and rate of water injection. Condensation of the vapor and collection of the condensate are accomplished by a condenser using a water–glycol coolant loop and recovery subsystem of adequate capacity.

Another method of cooling fuel cells, primarily under reduced gravity, has been in a conceptual stage of development. In this method, the coolant fluid would be supplied to the distribution manifold under a slight pressure and conveyed to the heat source by capillary wicks. The resultant vapor develops a pressure head, which would be converted to a velocity head in the injector nozzle of an impulse pump. A pressure drop would thus appear at the vapor orifice. Condensate from the condenser would be carried into the vapor stream and accelerated in an accelerator barrel. The velocity head is partially converted to a pressure head, which is greater than the initial vapor pressure. This pressure rise, plus the pressure-gradient increase due to the capillary wicking, would force the liquid to flow into the fuel cell. Operation of the impulse pump is similar to that of a steam–water injector used on a boiler.

Note:

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(continued overleaf)

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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